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GOLD MÖSSBAUER ANALYSIS OF ANODE SLIMES

CONTRACT SERIAL NO. 99203-01-SQ
CONTRACT REQUISITION NO. 23440-9-9203
CONTRACTOR: ATOMIC ENERGY OF ANADA

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Work on the project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada.

DSS FILE NO: 028SQ.23440-9-9203
DSS CONTRACT SERIAL NO: 23440-9-9203/01-SQ
CANMET PROJECT NO: - - -
CANMET SCIENTIFIC AUTHORITY: MR. J.E. DUTRIZAC

MICROMEDIA

9 pp

1991 JANUARY

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1990 December 19

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Mössbauer spectroscopy of the 77.3 keV γ-rays in ^{197}Au has been used to determine the chemical form of gold in an anode slimes sample. Measurements were performed using a ^{197}Pt Mössbauer source in a transmission geometry. The source of ^{197}Pt was obtained by irradiating ^{196}Pt in the neutron flux of a reactor. ^{197}Pt β-decays to ^{197}Au with a half-life of 18 h. The γ-rays were detected with an intrinsic Ge detector. During the measurements the source and the absorber were kept at liquid helium temperature (4.2 K). The thickness of the absorber was 400 mg/cm^2. The scheme of the experimental arrangement is shown schematically in Figure 1.

Obtaining a high-quality spectrum proved to be very difficult because of the small content of Au and large content of heavy elements in the specimen. The chemical analysis of the investigated specimen #1 (raw slime) indicated the following elements (wt%): Cu (13.2), Ag (21.2), Se (9.86), Ni (0.41), Pb (~20) and Au (~0.6).

The spectrum presented in Figure 2 was obtained in three consecutive runs, each lasting 2 days and with the ^{197}Pt source irradiated three times. The spectra were added and least-square fitted assuming a Lorentzian shape of absorption lines. The best fit was obtained assuming a superposition of a single line and a quadrupole-split doublet, as shown in Figure 3. The parameters of the fit are given in Table 1.

The result can be interpreted as follows:

1. The single, fairly broad line can be attributed to a gold-rich alloy. The composition of this alloy could be, for instance, $Au_{60}Ag_{40}$ or $Au_{80}Cu_{20}$ (1).

2. The quadrupole-split doublet best matches fischesserite Ag_3AuSe_2. The parameters of this compound, recently established by Wagner et al. (2), are IS = 1.20 ± 0.01 mm/s and QS = 4.96 ± 0.03 mm/s. The valency of Au is Au(I).

3. The relative intensity of the singlet and the doublet makes it possible to estimate the relative amounts of gold in the two phases: 27% in an alloy and 73% in fischesserite.

Table 2 gives a compilation of the Mössbauer parameters of relevant inorganic gold compounds (2-4). The survey excludes the presence in the anode slime sample of most of the compounds, except Ag_3AuSe_2, and possibly Ag_3AuTe_2.

TABLE 1: Parameters of the Mössbauer Spectrum of the Raw Anode Slimes Sample (#1)

	IS* Isomer Shift (mm/s)	QS Quadrupole Splitting (mm/s)	W Line Width (mm/s)	F Fractional Area (%)
Single Line	-0.30 ± 0.10	-	2.94 ± 0.47	27 ± 3
Quadrupole Doublet	1.22 ± 0.04	5.03 ± 0.06	2.03 ± 0.10	73 ± 3

*IS is given relative to a platinum metal source. To refer IS to metallic gold, +1.23 mm/s has to be added to the tabulated values.

TABLE 2: Mössbauer Parameters of Selected Gold Compounds

	IS* Isomer Shift (mm/s)	QS Quadrupole Splitting (mm/s)
Anode Slime	1.22 ± 0.04	5.03 ± 0.06
Ag_3AuTe_2	1.19 ± 0.02	4.56 ± 0.05
Ag_3AuSe_2	1.20 ± 0.01	4.96 ± 0.03
Ag_3AuS_2	1.59 ± 0.01	5.36 ± 0.03
$AuAgTe_2$	1.4 - 1.6	2.4 - 2.7
Au in Te	3.1	-
Au Metal	-1.23	-
Au_2S	1.38 ± 0.06	5.89 ± 0.13
Au_2S_3	0.046 ± 0.09	4.87 ± 0.16
AuCN	2.30 ± 0.04	7.95 ± 0.11
$KAu(CN)_2$	3.13 ± 0.05	10.20 ± 0.10
AuCl	-1.39 ± 0.03	4.56 ± 0.09
$AuCl_3$	0.57 ± 0.09	0.75 ± 0.08
AuO(OH)	1.38 ± 0.03	1.71 ± 0.06
$Na_3Au(S_2O_3)_2$	0.07 ± 0.03	0.71 ± 0.04
$Pb_3Au(Te,Sb)S_{5-8}$	1.6	3.4

*IS is given relative to a platinum metal source.

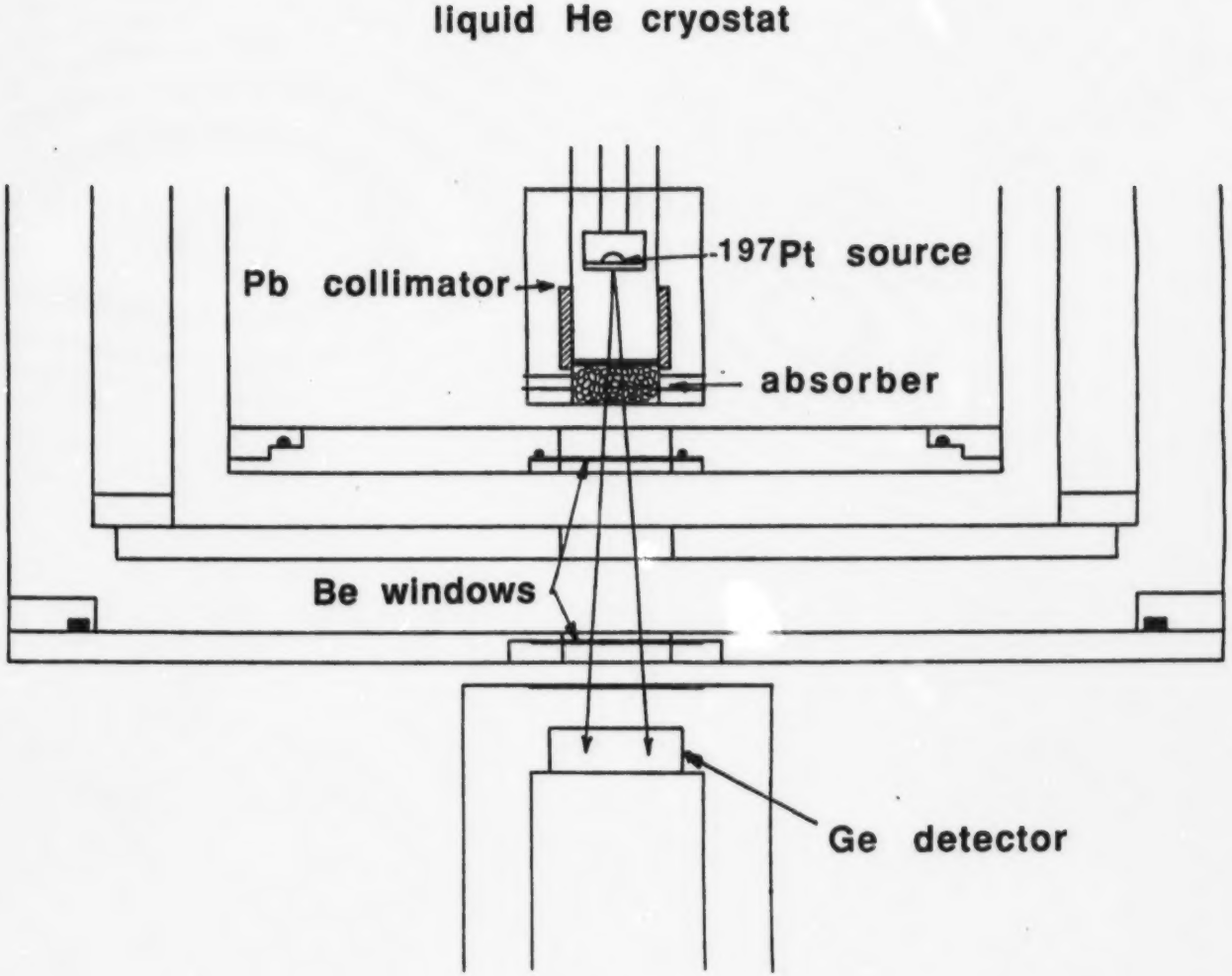

Fig. 1. A schematic view of the apparatus used for measuring the Mössbauer spectra of gold in the anode slimes.

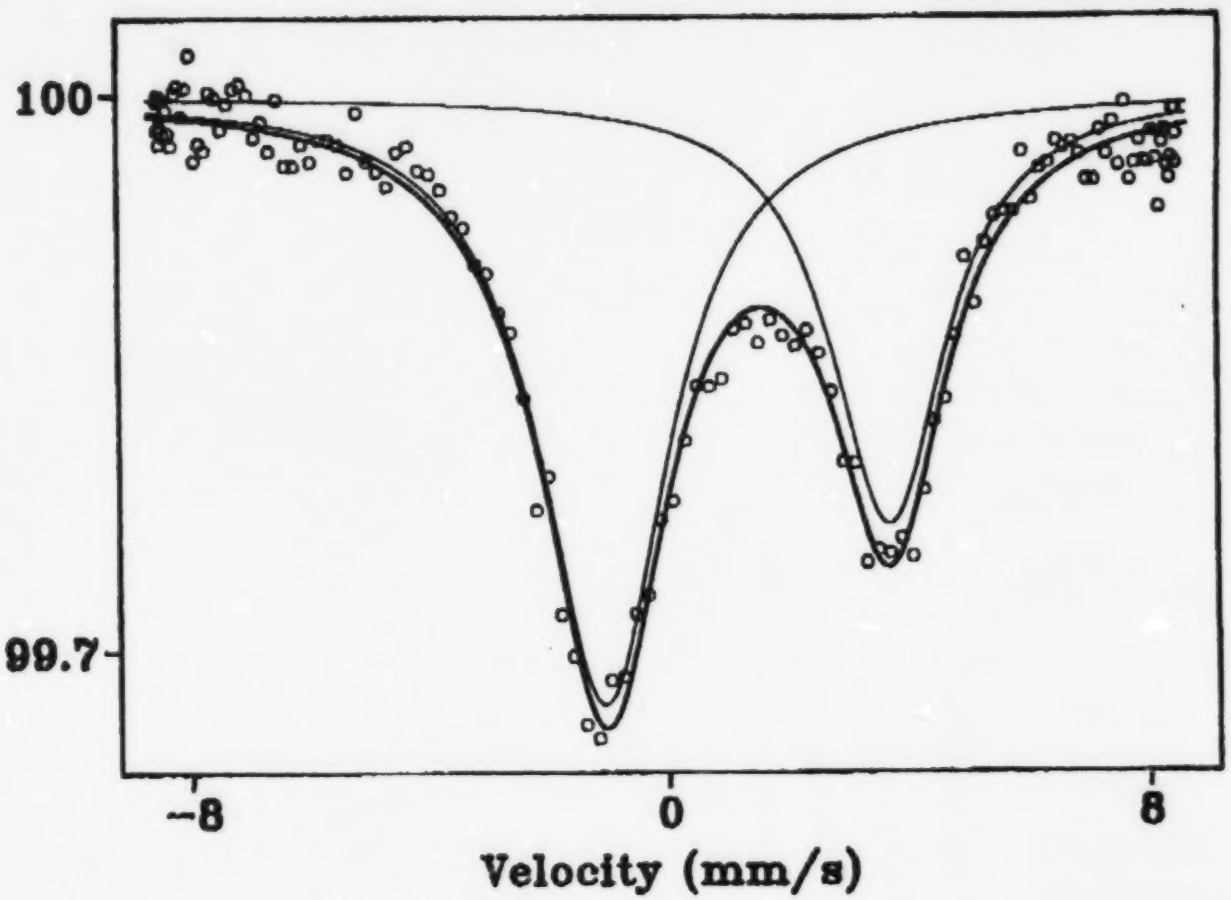

Fig. 2. ^{197}Au Mössbauer spectrum of the anode slimes fitted with two single lines.

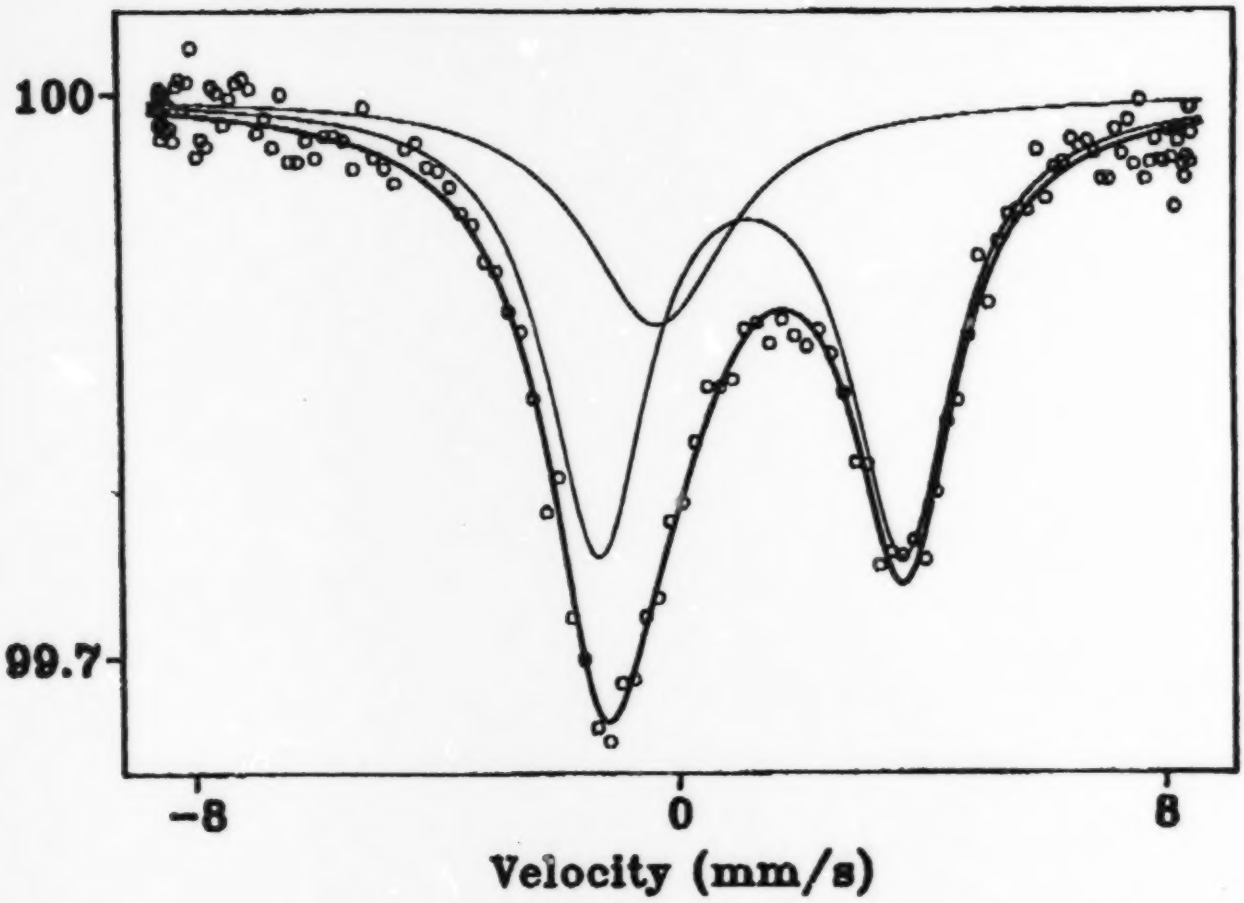

Fig. 3. ^{197}Au Mössbauer spectrum of the anode slimes fitted with a singlet and a doublet.

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1990 December 19

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